

Automated Breathing and Metabolic Simulator (ABMS) Evaluation of N95 Respirator Use with Surgical Masks

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Project Goals

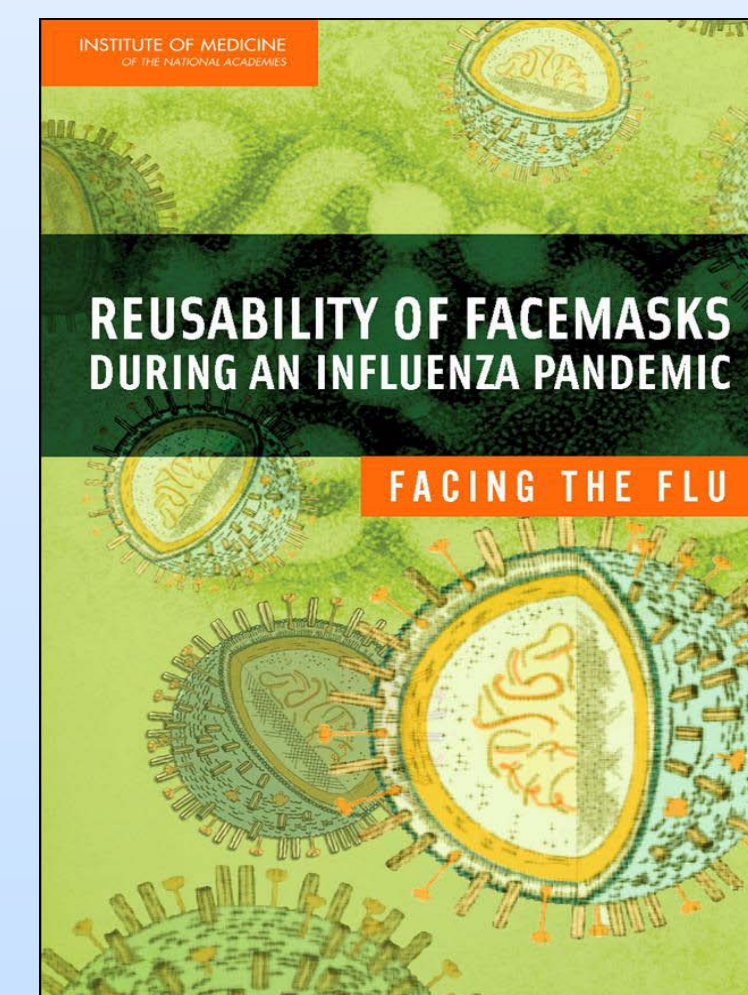
Use an automated breathing and metabolic simulator (ABMS)-based test to evaluate the inhaled carbon dioxide (CO₂) and oxygen (O₂) concentrations of NIOSH approved N95 particulate filtering facepiece respirators (N95FFR) with and without a FDA cleared surgical mask as a protective cover.

Stakeholders

- Respirator manufacturers
- Health care workers
- FDA
- ISO
- Emergency responders
- CDC
- IOM

Background

- In the United States, predictions of more than an estimated 90 million N95FFR could be used by health care workers for each wave of an influenza pandemic.
- The increased reliance on N95FFR is estimated to severely strain or exhaust respirator supplies.
- IOM recommendation: The useful life of N95FFR could be extended by adding a surgical mask protective cover.
- Previous research has reported higher CO₂ and lower O₂ concentrations in N95FFR alone (see references)*.
- Currently, no NIOSH certification test is available to measure inhaled CO₂ and O₂ concentrations in non-CBRN air-purifying respirators.



- Respirator models were selected from those used in the U.S. Strategic National Stockpile (SNS) and market analysis. One surgical mask (SM) was selected from the SNS.
- All tests were conducted using the ABMS, which simulates human metabolism, minute ventilation, and breathing waveforms. The ABMS CO₂ protocol consists of the following levels of O₂ consumption, CO₂ production, and minute ventilation performed consecutively for a minimum of five minutes each: 0.5, 0.4, and 10 L/min STPD; 1.0, 0.8, and 25 L/min STPD; 1.5, 1.3, and 38 L/min STPD; 2.0, 1.9, and 62 L/min STPD; 2.5, 2.5, and 70 L/min STPD; and 3.0, 3.1, and 80 L/min STPD, respectively.

Results from 18 paired-valve models

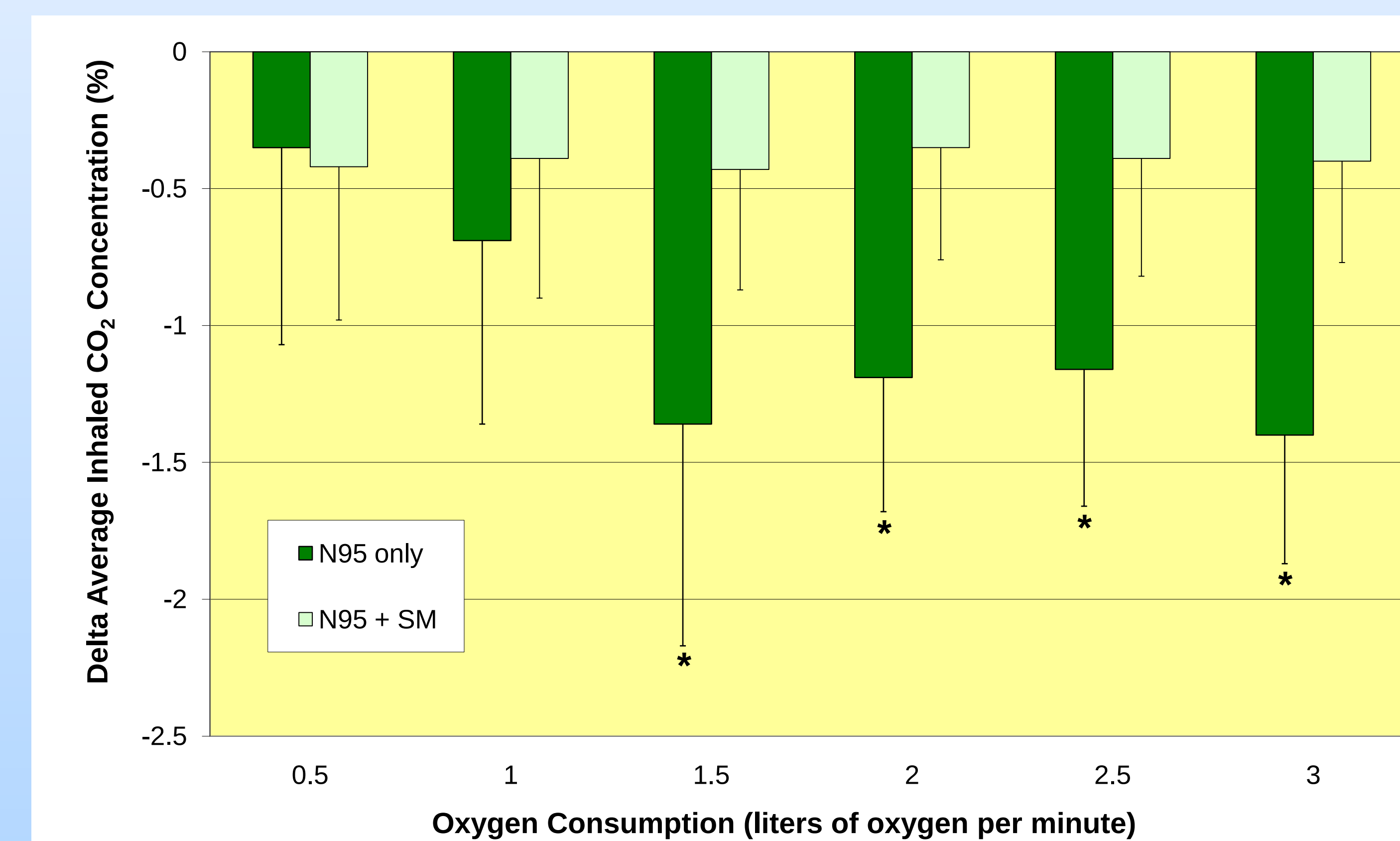


Figure 1. Mean delta (N95FFR with exhalation valve minus N95FFR without exhalation valve) of average inhaled CO₂ concentration (mean ± SD) in N95FFR with and without surgical mask covers for all levels of oxygen consumption. N95FFR without surgical mask covers (N95 only) = dark bars, N95FFR with surgical mask covers (N95 + SM) = light bars
* Significantly different from N95 + SM, p<0.05

Disclaimer: The findings and conclusions in this poster have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

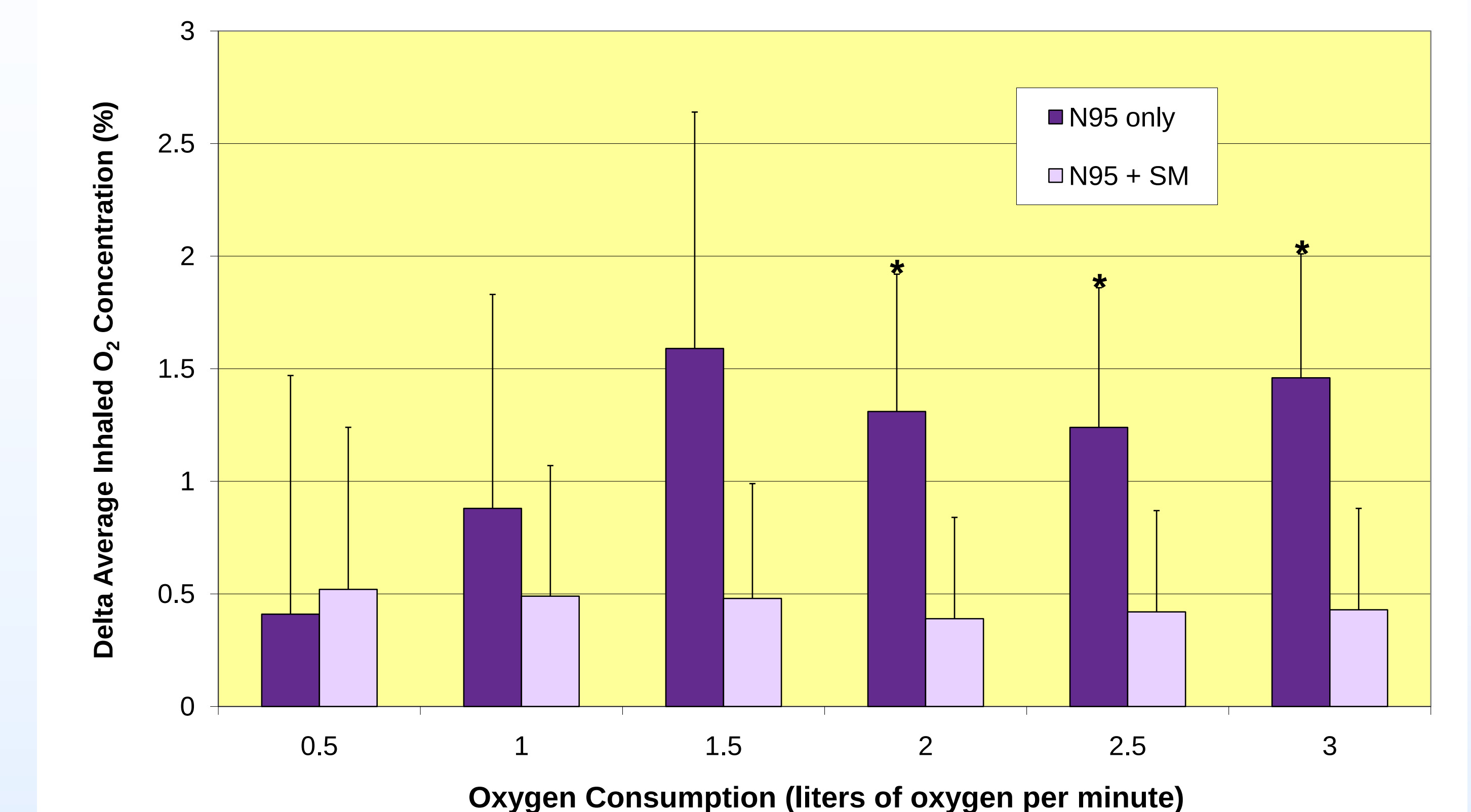


Figure 2. Mean delta (N95FFR with exhalation valve minus N95FFR without exhalation valve) of average inhaled O₂ concentration (mean ± SD) in N95FFR with and without surgical mask covers for all levels of oxygen consumption. N95FFR without surgical mask covers (N95 only) = dark bars, N95FFR with surgical mask covers (N95 + SM) = light bars
* Significantly different from N95 + SM, p<0.05

Conclusions

- N95FFR with a SM cover (light bars) produced small and similar deltas in average inhaled CO₂ and O₂ concentrations among a spectrum of energy expenditures in the matched models of N95FFR paired with and without exhalation valves.
- Below 1.5 L/min oxygen consumption, there were no significant differences in the delta of average inhaled CO₂ and O₂ between N95FFR and N95FFR+SM among the matched models of N95FFR paired with and without exhalation valves.

References*

- Turner, N., E. Sinkule, S. Hota (2003). Automated Breathing and Metabolic Simulator (ABMS) CO₂ Test for Powered and Non-Powered Air-Purifying Respirators, Airline Respirators and Gas Masks. National Occupational Research Agenda Symposium, Arlington, VA.
- Sinkule, E. and Turner, N. (2004) Inhaled Carbon Dioxide and Oxygen Concentrations in Three Escape Hood Respirators During Rest and Exercise. *Medicine & Science in Sports & Exercise* 36: S245.